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Design and Structural Analysis of Sandwich panels Used in Aerospace Applications

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Abstract:

Sandwich theory describes the behavior of a beam, plate, or shell which consists of three layers - two face sheets and one core. The most commonly used sandwich theory is linear and is an extension of first order beam theory. Linear sandwich theory is of importance for the design and analysis of sandwich panels, which are of use in building construction, vehicle construction, airplane construction and refrigeration engineering. Sandwich cross sections are composite. They usually consist of a low to moderate stiffness core which is connected with two stiff exterior face-sheets. The composite has considerably higher shear stiffness to weight ratio than an equivalent beam made of only the core material or the face-sheet material. The composite also has a high tensile strength to weight ratio.

This laboratory exercise investigates the fundamental aspects of designing composite sandwich panels. Composite sandwich panels are used in applications that required a light weight, high strength structure. Common applications of sandwich panels that students maybe familiar with are surfboards, wake boards, and corrugated cardboard. Sandwich panels are often used in aerospace applications, such as wing flaps, aircraft floors and overhead storage bins. we build, test and analyze the strength and stiffness of composite sandwich panels from readily available materials.Hence our intension is to do the analysis on a well designed sandwich panel arrangements used for Aircraft Wing & fuselage Structures & other Defense applications by using ANSYS.

INTRODUCTION (Heading 1):

Composite materials are widely used in today's modern world. With the advent of new materials, production techniques and new application areas, etc., composite materials have become one of the most attractive areas in engineering.

As in many areas of engineering, generic applications are based on analytical methods and with the increasing complexity of the geometries, boundary conditions and material, in almost every case, the use of analytical methods become very tedious if not impossible. At this point, the use of computational methods comes into picture. With the help of computational methods, namely finite element method (FEM) for structural analyses, highly complicated problems can be handled with great accuracy. The disadvantage of using computational methods is that, in order to get accurate results, too much computational time is needed, and this increases when the problem becomes more complex. In addition, FEM models require a detailed study before the model is sent to the solver.In this thesis, honeycomb structures (HC), which is a specific type of composite structure are investigated. HC structures are mostly used in sandwich structures. Because of the web-type structure of the HC's, the sandwich structure made from HC's is relatively complex from the modeling and analysis point of view. The goal in this post-graduate study is to generate an orthotropic equivalent model that can be used instead of the honeycomb structure itself. Thus, a great decrease in the preprocessor time and computation time can be achieved.

The generated equivalent model can be used mostly in the preliminary design stage of the design process. Because of the nature of the preliminary design stage, the requirements, the geometries, and the loads of any kind, change very often, which resolves the problem to get the results for the updated design. In addition to these, there are many different HC's with different cell sizes, wall thicknesses and material that can be readily found on the market. Hence, instead of using a finite element model that fully models the details, an equivalent model an be used to reduce the time spent for the analysis of the HC structure. In the following chapters, it will be seen that the equivalent model gives macro scale results, which means that in order to get the results for the micro scale, i.e. the stresses on the cell walls and local displacements, a more detailed 3-D model should be used.

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I.EASE OF USE:

A composite material is made by combining two or more materials to give a unique combination of the properties of the constituent materials. The advantage of the composites is that they usually exhibit the best qualities of the constituents and some qualities that neither constituent possesses. The properties that can be improved include.

COMPOSITE MATERIALS:

A composite material is made by combining two or more materials to give a unique combination of the properties of the constituent materials. The advantage of the composites is that they usually exhibit the best qualities of the constituents and some qualities that neither constituent possesses. The properties that can be improved include:

•Strength
•Stiffness
•Corrosion resistance
•Wear resistance
•Attractiveness
•Weight
•Fatigue life
•Thermal insulation
•Thermal conductivity
•Acoustical Insulation

The composite materials are not “new”. Since ancient times mankind has used composite materials in different areas. Straw was used to strengthen mud bricks. Medieval swords and armor were constructed with layers of different materials. In the Mongolian arcs, compressed parts that are made of corn, and stretched parts that are made of wood and cow tendons were glued together .

Although the use of composite materials is not new, the history of modern composites probably began in 1937 when salesmen from the Owens Corning Fiberglass Company began to sell fiberglass to interested parties around the United States. In 1930, fiberglass had been made, almost by accident in 1930, when an engineer became intrigued by a fiber that was formed during the process of applying lettering to a glass milk bottle . Since then, many different types of composite materials have been invented and numerous studies performed on the mechanics of composite structures.

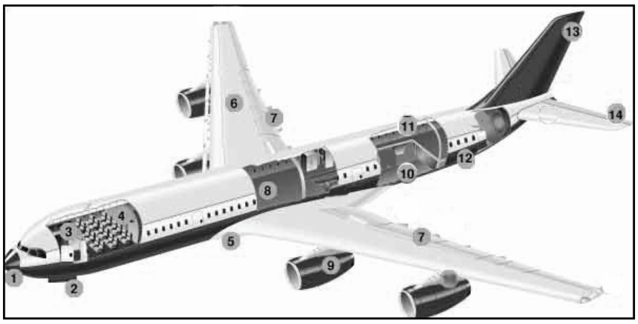
The range of application of composite materials is very large; some of the main application areas are listed below

» Electronics
» Buildings
» Road transportation
» Rail transportation
» Marine Transportation
» Air & Space Transportation

MAIN APPLICATIONS OF HONEYCOMB SANDWICH STRUCTURES:

Commercial aerospace:

Figures 1.4, 1.5, and 1.6 show typical applications of sandwich structures in commercial aerospace vehicles. These examples show the extent to which sandwich composite structures are utilized in the structural parts.



» Radome: Specialized glass Prepregs. Flex core honeycomb.
» Landing Gear Doors and Leg Fairings: Glass/carbon Prepregs, honeycomb
» And Redux bonded assembly. Special process honeycomb.
» Galley, Wardrobes, Toilets: Fabricated Fibrelam panels.
» Partitions: Fibrelam panel materials.
» Wing to Body Fairing: Carbon/glass/aramid Prepregs. Honeycombs.

Redux adhesive:

» Wing Assembly: (Trailing Edge Shroud Box) Carbon/glass Prepregs.
» Nomex honeycomb. Redux bonded assembly

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THE ORIGINS OF SANDWICH TECHNOLOGY:

The first successful landing of a space ship on the moon on 20 July 1969 was the result of the successful application of a number of new technologies including rocketry, computers and sandwich construction. Although public interest centred on rocketry and computer technology, it was only with the help of sandwich technology that a shell of the spacecraft could be constructed that was light in weight and yet strong enough to sustain the stresses of acceleration and landing. Figure 1.1 shows the wall construction of the Apollo capsule which consisted of two interconnected sandwich shells. Figure 1.2 shows details of the outer shell, which comprised two thin steel facings and a honeycomb core. The inherent advantage of sandwich construction is immediately apparent, namely, high strength and rigidity at low weight.

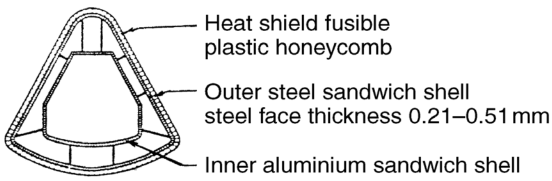


Fig. 2.1: Sandwich construction of the Apollo capsule.

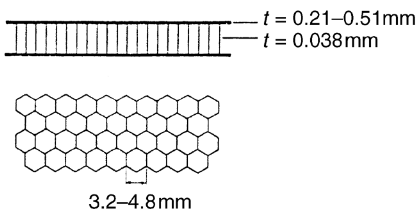


Fig.: Cellular sandwich forming the outer shell of the Apollo capsule.

MATERIALS USED IN SANDWICHPANELS

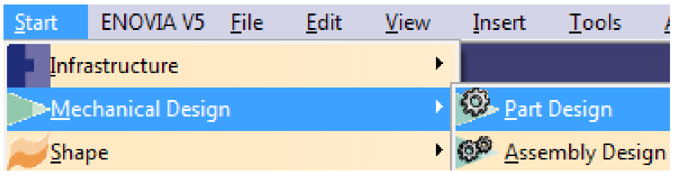
Aluminum:

Aluminum is the third most abundant element (after oxygen and silicon), and the most abundant metal, in the Earth's crust. It makes up about 8% by weight of the Earth's solid surface. Aluminum metal is too reactive chemically to occur natively. Instead, it is found combined in over 270 different minerals. The chief ore of aluminum is bauxite. Aluminum is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminum and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials. The most useful compounds of aluminum, at least on a weight basis, are the oxides and sulfates. Despite its prevalence in the environment, aluminum salts are not known to be used by any form of life. In keeping with its pervasiveness, aluminum is well tolerated by plants and animals. Due to their prevalence, potential beneficial (or otherwise) biological roles of aluminum compounds are of continuing interest.

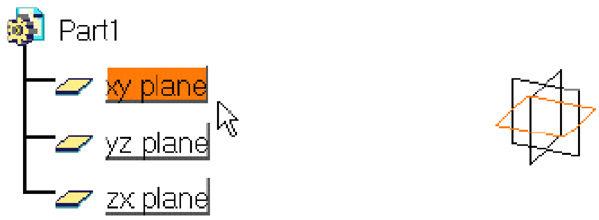
MODELING OF SANDWICH PANELS WITH BIO FOAM CORE:

Step-1 :- (Starting Catia V5)

Select Start Mechanical Design Part design from the main bar

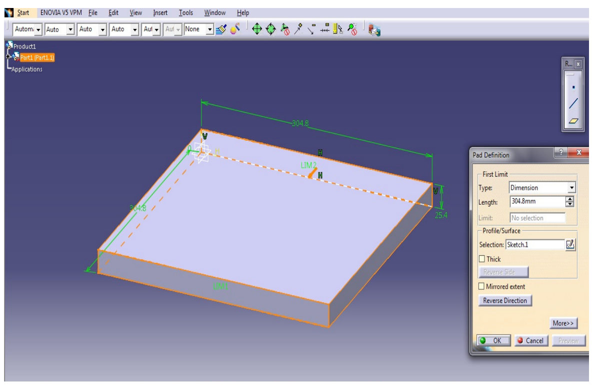


Select the XY plane



Step: 2(Model of Upper face sheet 3D Model)

- Select→Sketch→Draw a rectangle with 1ft /1inch
- Exit work bench
- By using pad option →extrude up to 1ft



Screen Model of face sheet 1(Biofoam)

Select→Sketch→Draw another rectangle with 1ft /1inch
Exit work bench
By using pad option →extrude up to 1ft

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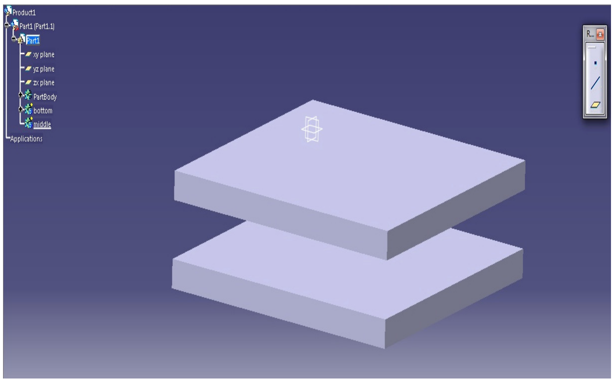
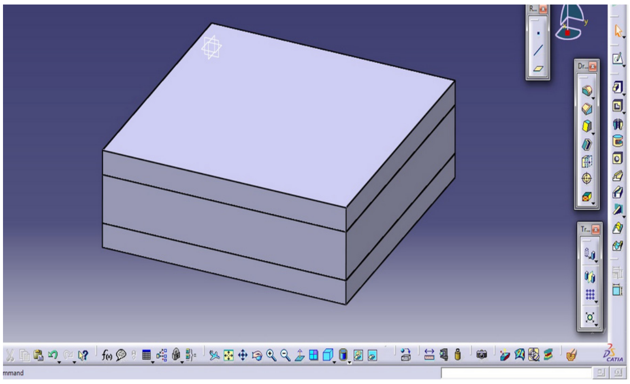


Screen 5.2: Model of Face sheet 2 (Biofoam)

Select XY – plane →Draw another rectangle with same dimensions with 2 inches gap b/w them
Select → rectangle →with 2 inch thickness & extrude it up to 1feet



Screen 5.3: Model of Bio foam Core

Model of Bio foam Core
Save it as IGS format & catia v.part file

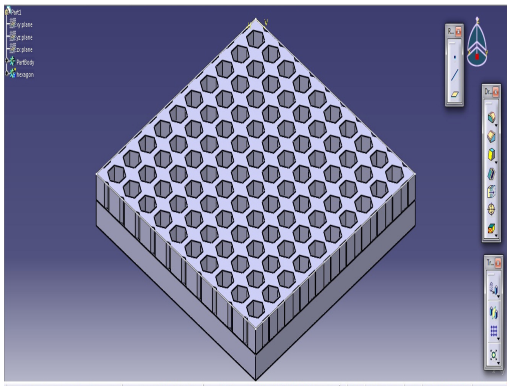
BASIC METHODOLOGY OF ANSYS:

Ansys is followed up by the method called Finite Element Modeling Methods (FEM)\

Finite element method:

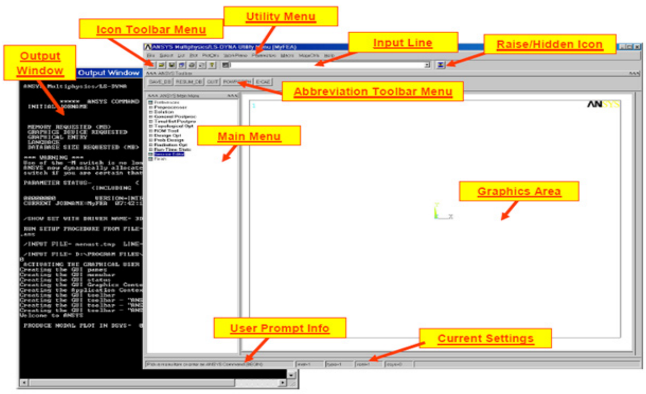
The finite element method (FEM) (its practical application often known as finite element analysis (FEA) is a numerical technique for finding approximate solutions of partial differential equations (PDE) as well as of integral equations. The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method, Runge-Kutta, etc.

In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that errors in the input and intermediate calculations do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantages. The Finite Element Method is a good choice for solving partial differential equations over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation). Another example would be in Numerical weather prediction, where it is more important to have accurate predictions over developing highly-nonlinear phenomena (such as tropical cyclones in the atmosphere, or eddies in the ocean) rather than relatively calm areas.



Screen 5.5 : Model of Honey comb core

Layout of ansys window:



Screen 6.1 ANSYS window

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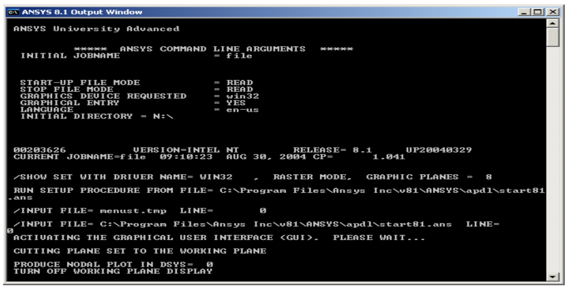
ANSYS GRAPHICAL USER INTERFACE (OUT PUT WINDOW):

After starting ANSYS, two windows will appear. The first is the ANSYS 8.1 Output Window:



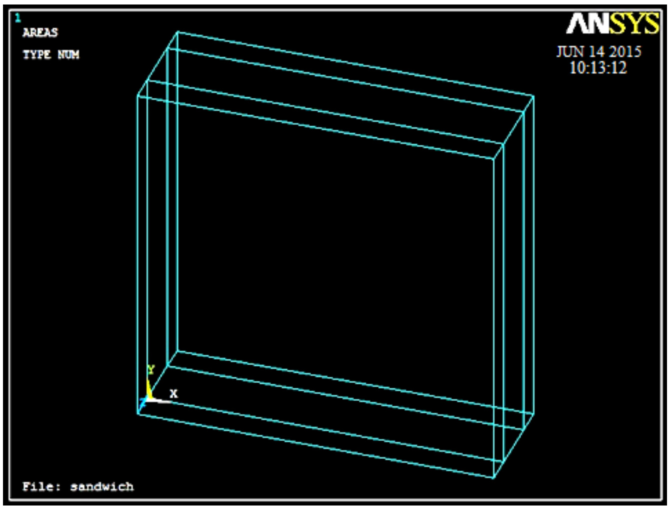
Screen 6.2 : output window

This window displays a listing of every command that ANSYS executes. If you encounter problems, this is a good place to look to see what ANSYS is doing or has done. This is one location where you will find all of the warnings and error messages that appear and the command that generated the warning/error.The second window is the ANSYS Research FS graphical user interface.

This is divided into 4 sections (shown on next page):
ANSYS Utility Menu
ANSYS Toolbar Menu
ANSYS Main Menu
Display window
Each section will be discussed in further detail below.

STRUCTURAL ANALYSIS ANALYSIS OF BIO FOAM SANDWICH PANEL:

Import the CATIA file of bio foam in to ANSYS



Screen 7.1 Catia file imported in ANSYS (Bio foam)

Step-1:- Preferences→Structural→H-method→Ok

Step- 2:- Preprocessor→Element Type →Add→Add→Solid→Tet 4 Node 187

Step-3:-

Material properties→Material models→Structural→linear →Elastic→Isotropic→E=69000 N/mm^2 →PRXY=0.334

Select new model→E=0.02e5→PRXY=0.3

Step-4:-

a) Meshing →Mesh attributes→picked volumes→Select the face sheets →as a material 1→apply →Select material as properties for middle block →ok
b) Size controls→Smart Size →Basic→LVL sixe level 10 (coarse) →ok
c) All areas→manual size→areas→all areas→Element edge length=20→ok
d) Mesh→Volumes→free→pick all→ok

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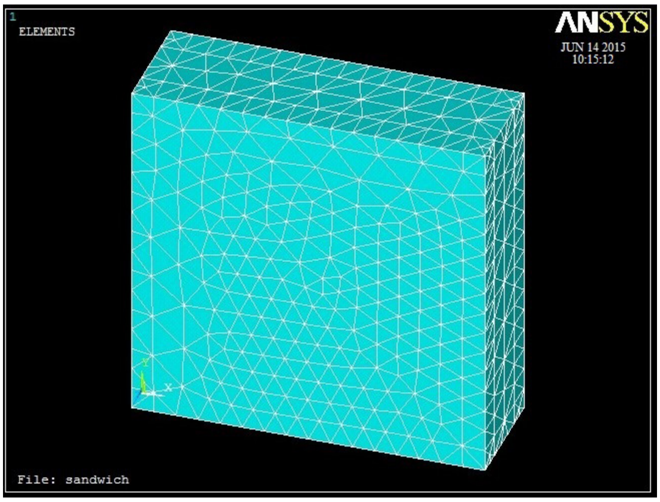
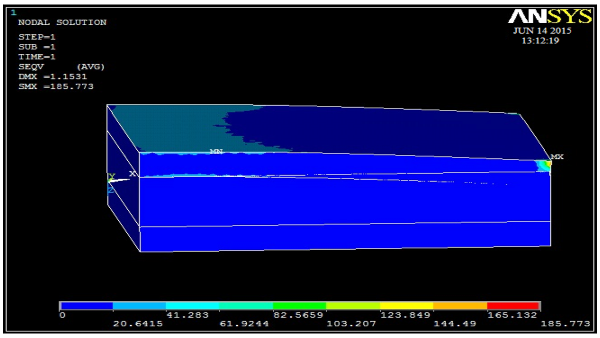


Screen 7.2: Meshing (Bio foam)

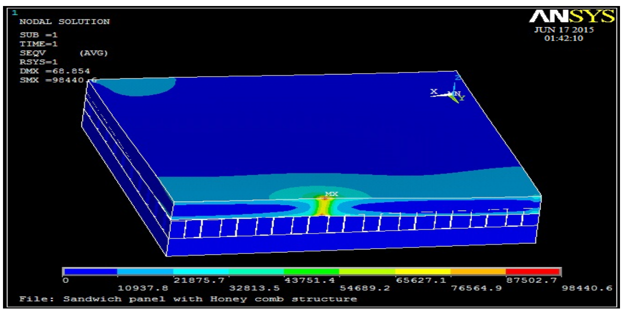
Step: 5:- (Solution)

Define loads →apply→structural→displacement→on Areas→select→one side of panel is fixed with ALL DOF→ok

Force or moment→on key points→Select the top most corner points on the free end →ok→FZ→2000 KN at free end



Screen 7.10 : Von misses Stress



Screen 7.20 :Von misses Stress

RESULTS:

After fixing the one end with all DOF, assuming the panels as a cantilever beam, applied load up to 2000 KN Point loads in Z - direction. At the free end & observed the behavior in Stress in X, Y, Z –Directions & Von- misses Stress. Hence the results are at Maximum & Minimum Stresses are at all the directions & Displacement of all components.

Displacement and Stresses acting on a Sandwich panel with Bio foam core:

Displacement of X- Component
a)Minimum = -0.072295
b)Maximum = 0.078845

Displacement of Y-Component
a)Minimum = -0.015227
b)Maximum = 0.019178

Displacement of Z-Component
a)Minimum = -0.976E-03
b)Maximum = 1.15025

Stresses at X – Direction
a)Minimum = -42.9251
b)Maximum = 41.8158

Stresses at Y- Direction
a)Minimum = -21.8146
b)Maximum = 35.7779

Stress at Z- Direction
a)Minimum = -184.779
b)Maximum = 20.9707

After Fixing the one end with all DOF, assuming the panels as a cantilever beam, applied load up to 2000 KN UDL throughout the area of the beam in Z – direction . At the free end & observed the behavior in Stress in X, Y, Z –Directions & Von- misses Stress. Hence the results are at Maximum & Minimum Stresses are at all the directions & Displacement of all components.

CONCLUSION:

The aim of this project is to decrease the weight of an aircraft, so by using the light weight composite materials we can decrease the weight they are nothing but Sandwich panels.Even though they should be high strength materials with more stiffness. So by assuming them as a cantilever beam, by applying loads on it we can get the minimum & maximum stresses acting on a sandwich panels when the loads are acting on the free end. With the analysed results for the given parameters Hereby we conclude that

» Honey comb structures have much stiffness & heavy weight

» Whereas bio foam with same properties with light weight

» So we can justify that by using bio foam we can decrease the weight of an aircraft

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References:

» Structural and Failure Mechanics of Sandwich Composites by L.A.
» Carlsson & G.A. Kardomateas
» Light Weight Sandwich Construction by J.M. Davies
» Plantema, F, J., 1966, Sandwich Construction: The Bending and Buckling of Sandwich Beams, Plates, and Shells, Jon Wiley and Sons, New York.
» Zenkert, D., 1995, An Introduction to Sandwich Construction, Engineering Materials Advisory Services Ltd, UK.
» http://www.sandwichpanels.org/articles/wing_repair.html
» http://www.sandwichpanels.org/articles/article_sandwichoanelcores.html
» www.wikipedia.com
» http://www.dspace.cam.ac.uk/bitstream/1810/236995/1/Design%20of%20Sandwich%20Structures,%20PhD%20Thesis,%20Achilles%20Petras.pdf